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Long-Term and Rapid Radio Variability of the Blazar 3C 454.3 in 2010–2017

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Abstract—The article presents the results of observations of the blazar 3C 454.3 (J2253+1608), obtained in 2010–2017 on the RATAN-600 radio telescope of the Special Astrophysical Observatory at 4.6, 8.2, 11.2, and 21.7 GHz and on the 32-m Zelenchuk and Badary radio telescopes of the Quasar VLBI Network of the Institute of Applied Astronomy at 4.84 and 8.57 GHz. Long-term variability of the radio emission is studied, as well as variability on time scales of several days and intraday variability (IDV). Two flares were observed in the long-term light curve, in 2010 and in 2015–2017. The flux density at 21.7 GHz increased by a factor of ten during these flares. The delay in the maximum of the first flare at 4.85 GHz relative to the maximum at 21.7 GHz was six months. The time scale for variability on the descending branch of the first flare at 21.7 GHz was $\tau_{\rm var} = 1.2$ yrs, yielding an upper limit on the linear size of the emitting region of 0.4 pc, corresponding to an angular size of 0.06 mas. The brightness temperature during the flare exceeded the Compton limit, implying a Doppler factor $\delta = 3.5$, consistent with the known presence of a relativistic jet oriented close to the line of sight. No significant variability on time scales from several days to several weeks was found in five sets of daily observations carried out over 120 days. IDV was detected at 8.57 GHz on the 32-m telescopes in 30 of 61 successful observing sessions, with the presence of IDV correlated with the maxima of flares. The characteristic time scale for the IDV was from two to ten hours. A number of IDV light curves show the presence of a time delay in the maxima in the light curves for simultaneous observations carried out on the Badary and Zelenchuk antennas, which are widely separated in longitude. This demonstrates that the IDV most like arises in the interstellar medium.

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1. INTRODUCTION

The source 3C 454.3 is a well known active galactic nucleus (AGN). The optical object with which the radio source is identified is classified as a highly polarized quasar with a redshift of $z = 0.859$ and an optical magnitude of $V = 16.1^m$ [1, 2]. The Galactic latitude of the source is $b = -38.2°$. Strong variability of the flux density of the blazar 3C 454.3 has been detected throughout the electromagnetic spectrum.

Monitoring of the flux density in the radio has been carried out on the 26-m telescope of the University of Michigan at 4.8, 8, and 14.5 GHz [3], the 14-m Metsahovi telescope (Finland) at 37 GHz [4], and the 22-m telescope of the Crimean Astrophysical Observatory at 22.2 GHz and 36.8 GHz [5]. The source variability includes flares with various amplitudes.

Substantial variability is also observed in the optical, infrared [6], X-ray [7], and gamma-ray [8]. Flares reaching 5^m have been observed in the optical.

A large-amplitude flare was observed at five frequencies from 8 to 43 GHz in 2005–2006 [7], with the flare amplitudes displaying a strong dependence on the frequency. The flux density increased to 20 Jy at 37 and 43 GHz, with the flare maximum being fixed in the middle of March 2006. At the same time, no flare was visible at 8 GHz. This same flare was observed at 14.5 and 36.8 GHz, and also in the optical (R) [5]. The various light curves were correlated, with

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